

FINAL REPORT
APRIL 2000

REPORT NO. 00-03



2.75-INCH ROCKET HYDRA PALLET MIL-STD-1660 FIRST ARTICLE TEST

Prepared for:
U.S. Army Armament Research, Development
and Engineering Center
ATTN: AMSTA-AR-WEP-RP
Rock Island, IL 61299-7300

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**VALIDATION ENGINEERING DIVISION
MCALESTER, OKLAHOMA 74501-9053**

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14. ABSTRACT

The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SOSAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct a First Article Test per MIL-STD-1660, Design Criteria for Ammunition Unit Loads on the 2.75-inch Hydra 70, PA150, Rocket Pallet produced by Delfasco of Tennessee, Greeneville, TN. Two of the three pallets submitted by Delfasco were evaluated using MIL-STD-1660 test requirements. No significant flaws were found in the two pallets during testing so the third pallet was not evaluated. As a result of the performance of the pallets during testing, the 2.75 inch, Hydra 70, PA150, Rocket Pallet produced by Delfasco is recommended for USA-wide use.

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April 2000

ABSTRACT

The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SOSAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct a First Article Test per MIL-STD-1660, Design Criteria for Ammunition Unit Loads on the 2.75-inch, Hydra 70, PA150, Rocket Pallet produced by Delfasco of Tennessee, Greeneville, TN. Two of the three pallets submitted by Delfasco were evaluated using MIL-STD-1660 test requirements. No significant flaws were found in the two pallets during testing so the third pallet was not evaluated. As a result of the performance of the pallets during testing, the 2.75 inch, Hydra 70, PA150, Rocket Pallet produced by Delfasco is recommended for USA-wide use.

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U.S. ARMY DEFENSE AMMUNITION CENTER

VALIDATION ENGINEERING DIVISION
MCALESTER, OK 74501-9053

REPORT NO. 00-03

**2.75-INCH ROCKET HYDRA PALLET
MIL-STD-1660 FIRST ARTICLE TESTING (FAT)**

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PART 1 – INTRODUCTION

A. **BACKGROUND**. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SOSAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct a First Article Test per MIL-STD-1660, Design Criteria for Ammunition Unit Loads on the 2.75-inch, Hydra 70, PA150, Rocket Pallet produced by Delfasco of Tennessee, Greeneville, TN.

B. **AUTHORITY**. This test was conducted IAW mission responsibilities delegated by the U.S. Army Operations and Support Command (Prov), Rock Island, IL. Reference is made to the following:

1. Change 6, AR 740-1, 18 August 1976, Storage and Supply Activity Operation.

2. IOC-R, 10-23, Mission and Major Functions of USADAC, 7 January 1998.

C. **OBJECTIVE**. The objective of the tests was to determine if the pallet and its associated metal adapters produced by Delfasco met MIL -STD-1660 test requirements prior to the acceptance of the pallets by the U.S. Army (USA).

D. **CONCLUSION**. Two of the three pallets submitted by Delfasco were evaluated using MIL -STD-1660 test requirements. No significant flaws were found in the two pallets during testing so the third pallet was not evaluated. As a result of the performance of the pallets during testing, the 2.75 inch, Hydra 70, PA150, Rocket Pallet produced by Delfasco is recommended for USA-wide use.

PART 2 - ATTENDEES

DATES PERFORMED: MARCH 29-31, 2000

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Burlington, VT 05401-4985

PART 3 - TEST PROCEDURES

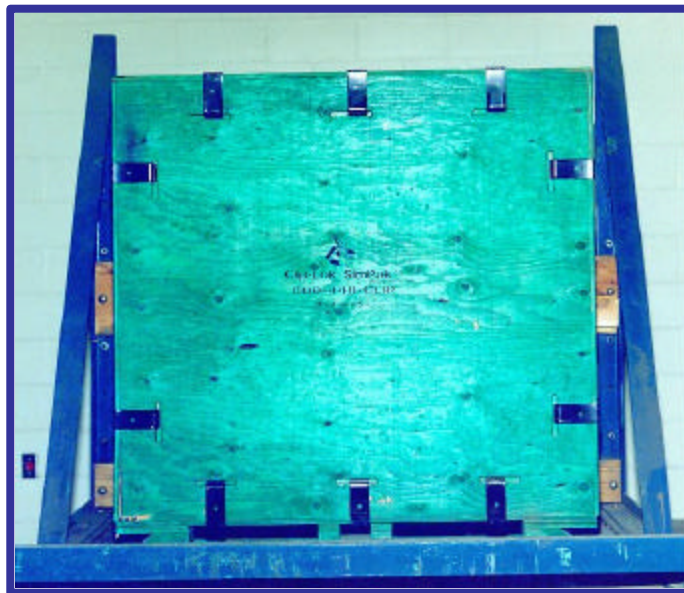
The test procedures outlined in this section were extracted from the MIL - STD-1660, Design Criteria for Ammunition Unit Loads, 8 April 1977. This standard identifies nine steps that a unitized load must undergo if it is to be considered acceptable. The four tests that were conducted on the test pallets are summarized below.

A. STACKING TEST. The unit load was tested to simulate a stack of identical unit loads stacked 16 feet high, for a period of one hour. This stacking load was simulated by subjecting the unit load to a compression weight equal to an equivalent 16-foot stacking height. The compression load was calculated in the following manner. The unit load weight was divided by the unit load height in inches and multiplied by 192. The resulting number was the equivalent compressive force of a 16-foot-high load. Figure 1 below shows an example of a unit load in the compression tester.



**Figure 1. Example of Compression Tester.
(2.75-inch Hydra 70, PA151 Rocket Pallet in the compression tester.)**

B. REPETITIVE SHOCK TEST. The repetitive shock test was conducted IAW Method 5019, Federal Standard 101. The test procedure is as follows: The test specimen was placed on (not fastened to) the platform. With the specimen in one position, the platform was vibrated at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of approximately 3 cycles per second. The frequency was steadily increased until the package left the platform. The resonant frequency was achieved when a 1/16-inch-thick feeler gage momentarily slid freely between every point on the specimen in contact with the platform at some instance during the cycle. Midway into the testing period, the specimen was rotated 90 degrees, and the test continued for the duration. Unless failure occurred, the total time of vibration was three hours. Figure 2 shows an example of the repetitive shock test.



**Figure 2. Example of the Repetitive Shock Test.
("Clip-Lok" pallet on the vibration table.)**

C. EDGEWISE ROTATIONAL DROP TEST. This test was conducted using the procedures of Method 5008, Federal Standard 101. The procedure for the edgewise rotational drop test is as follows: The specimen was placed on its skids with one end of the pallet supported on a beam 4-1/2 inches high. The height of the beam was increased if necessary to ensure that there was no support for the skids between the ends of the pallet when dropping took place, but was not high enough to cause the pallet to slide on the supports when the dropped end was raised for the drops. The unsupported end of the pallet was then raised and allowed to fall freely to the concrete, pavement, or similar underlying surface from a prescribed height. Unless otherwise specified, the height of drop for level A protection conforms to the following tabulation:

GROSS WEIGHT (WITHIN RANGE LIMITS)	DIMENSIONS OF ANY EDGE, HEIGHT OR WIDTH (WITHIN RANGE LIMITS)	HEIGHT OF DROPS ON EDGES	
		Level A (Inches)	Level B (Inches)
(Pounds)	(Inches)		
150 -250	60 - 66	36	27
250 -400	66 - 72	32	24
400 - 600	72 - 80	28	21
600 - 1,000	80 - 95	24	18
1,000 - 1,500	95 - 114	20	16
1,500 - 2,000	114 - 144	17	14
2,000 - 3,000	Above 145 - No limit	15	12
Above - 3,000		12	9



**Figure 3. Example of Edgewise Rotational Drop Test
(2.75-inch Hydra 70, PA151, Rocket Pallet)**

D. INCLINE-IMPACT TEST. This test was conducted by using the procedure of Method 5023, Incline-Impact Test of Federal Standard 101. The procedure for the incline-impact test is as follows: The specimen was placed on the carriage with the surface or edge to be impacted projecting at least 2 inches beyond the front end of the carriage. The carriage was brought to a predetermined position on the incline and released. If it were desired to concentrate the impact on any particular position on the container, a 4- by 4-inch timber would be attached to the bumper in the desired position before the test. The carriage struck no part of the timber. The position of the container on the carriage and the sequence in which surfaces and edges were subjected to impacts was at the option of the testing activity and depends upon the objective of the tests. This test was to determine satisfactory requirements for a container or pack, and, unless otherwise specified, the specimen was subjected to one impact on each surface that has each dimension less than 9.5 feet. Unless otherwise specified, the

velocity at the time of the impact was 7 feet-per-second. Figure 4 shows an example of this test.



**Figure 4. Example of the Incline-Impact Test.
(2.75 Inch, Hydra 70, PA151 Rocket Pallet on incline-impact tester.)**

E. SLING COMPATIBILITY TEST. Unit loads utilizing special design or non-standard pallets shall be lifted, swung, lowered and otherwise handled as necessary, using slings of the types normally used for handling the unit loads under consideration. Slings shall be easily attached and removed. Danger of slippage or disengagement when load is suspended shall be cause for rejection of the unit load.

PART 4 - TEST EQUIPMENT

A. COMPRESSION TESTER.

- | | |
|-----------------------|----------------------|
| 1. Manufacturer: | Ormond Manufacturing |
| 2. Platform: | 60- by 60-inches |
| 3. Compression Limit: | 50,000 pounds |
| 4. Tension Limit: | 50,000 pounds |

B. TRANSPORTATION SIMULATOR.

- | | |
|------------------|--------------------|
| 1. Manufacturer: | Gaynes Laboratory |
| 2. Capacity: | 6,000-pound pallet |
| 3. Displacement: | 1/2-inch amplitude |
| 4. Speed: | 50 to 400 RPM |
| 5. Platform: | 5- by 8-foot |

C. INCLINED PLANE.

- | | |
|------------------|--------------------|
| 1. Manufacturer: | Conbur Incline |
| 2. Type: | Impact Tester |
| 3. Grade: | 10 percent incline |
| 4. Length: | 12-foot |

PART 5 - TEST RESULTS

Two of three pallets submitted by Delfasco of Tennessee were inertly loaded to the specified design weight using two 4- by 4-inch lengths of lumber, two 2- by 4-inch lengths of lumber, and a quantity of ammunition simulant to bring each container individually to the required weight. Special care was taken to ensure that each container had the proper amount of weight in order to achieve a realistic pallet center of gravity (CG). Once properly prepared, the first two pallets were tested using MIL-STD-1660, Design Criteria for Ammunition Unit Loads, requirements. As a result of the good performance of the pallets during testing, the third pallet submission was not tested.

A. PALLET NO. 1.

Date:	29-30 March 2000
Weight:	2,245 pounds
Length:	78-1/2 inches
Width:	29-3/8 inches
Height:	43-1/2 inches

1. Compression Test. The test pallet was compressed with a load force of 9,285 pounds for 60 minutes. No damage was noted as a result of this test. See figure 5 below for a picture of the test pallet in the compression unit.



Figure 5. PA150 Hydra Test Pallet in the Compression Tester.

2. Repetitive Shock Test. The test pallet was vibrated 90 minutes at 225 RPM in the longitudinal orientation and 90 minutes at 168 RPM in the lateral orientation. See figure 6 below.



Figure 6. PA150 Hydra Test Pallet on the Vibration Table.

3. Edgewise Rotational Drop Test. The test pallet was edgewise rotationally dropped from a height of 15-inches on the longitudinal and 12 inches on the lateral drops due the load slipping off the wooden block after a height of 12 inches was exceeded during testing. No problems were encountered.

4. Incline-Impact Test. The test pallet was incline-impacted on all four sides with the pallet impacting the stationary wall from a distance of 8 feet. Again, no problems were encountered.

5. Sling Compatibility Test. The test pallet was lifted off of the ground using the top lift adapter by four points, three points, two diagonal points, two adjacent points, and one point. No shifting of the containers or permanent deformation of the top lift adapter was noted.

6. Post Test Inspection. Following completion of MIL-STD-1660 testing, the pallet was disassembled and inspected for damage. Minor weld cracks were noted on the pallet deck that were in line with the pallet posts. Some minor cracking was noted on the bottom of the support posts that were in contact with the skids. No significant damage was noted in the top or bottom adapters or the pallet deck. See figure 7 below.



Figure 7. Picture of First Pallet Taken After Testing.

B. PALLET NO. 2.

Date: 31 March 2000
Weight: 2,245 pounds
Length: 78-1/2 inches
Width: 29-3/8 inches
Height: 43-1/2 inches

1. Compression Test. The test pallet was compressed with a load force of 9,265 pounds for 60 minutes. No damage was noted as a result of this test.

2. Repetitive Shock Test. The test pallet was vibrated 90 minutes at 222 RPM in the longitudinal orientation and 90 minutes at 182 RPM in the lateral orientation. The center of gravity appeared to be too high which did not allow the pallet to vibrate at the desired amplitude. A wood cradle was made to brace the pallet towards the back of the vibration table to minimize the severity of the top heavy load and provide a vibration where the 1/16-inch feeler gage could move freely by each point of the pallet that was in contact with the platform. During both phases of testing no problems were noted.

3. Edgewise Rotational Drop Test. The test pallet was edgewise rotationally dropped from a height of 15-inches on the longitudinal and 12 inches on the lateral drops. See figure 8 below.



Figure 8. Edgewise Rotational Drop of Pallet No. 2

4. Incline-Impact Test. No damage was noted to the pallet or the adapters in the first successful pallet test so this test was not repeated.

5. Sling Compatibility Test. The test pallet was lifted off of the ground using the top lift adapter by only one point due to the successful completion of the first pallet adapter. No shifting of the containers or permanent deformation of the top lift adapter was noted.

6. Post Test Inspection. Following completion of MIL-STD-1660 testing, the pallet was disassembled and inspected for additional damage. Similar to the first pallet, minor weld cracks were noted on some of the areas on the pallet deck that were in line with the pallet posts. Again, some minor weld cracking on the post where they contact the skids was also noted. No significant damage was noted in the top or bottom adapters or the pallet deck.

7. Conclusion. Both pallets met MIL-STD-1660 Design Criteria for Ammunition Unit Loads with no major problems noted.

PART 6 – INTERIM TEST REPORT

INTERIM TEST REPORT

**VALIDATION ENGINEERING DIVISION
U.S. ARMY DEFENSE AMMUNITION CENTER
MCALESTER, OKLAHOMA 74501-9053**

1. **TEST TITLE:** 2.75-Inch Rocket Hydra Pallet
MIL-STD-1660 FAT Test
2. **TEST NUMBER:** 00-03
3. **DATES OF TESTS:** 29 - 31 March 2000
4. **ITEM TESTED:** 2.75-Inch Rocket Hydra metal pallets and associated adapters.
5. **PURPOSE:** To determine if the FAT pallets submitted meet MIL-STD-1660 first article requirements prior to manufacturing. Note: Manufacturing process modified to include a straightening operation to the deck.
6. **TEST ENGINEER:** William Meyer
7. **TEST OBSERVERS:** Arnold Jewett, General Dynamics Ordnance Systems,
Burlington, VT

Michael Bartosiak, DAC, SIOAC-DEM
8. **TESTS CONDUCTED:** MIL-STD-1660
 - a. Stacking Test.
 - b. Repetitive Shock Test.
 - c. Edgewise Rotational Drop Test.
 - d. Incline-Impact Test.
 - e. Sling Compatibility Test.
9. **TEST OBSERVATIONS:** During both series of tests, minor weld cracks were noted on the pallet deck in line with the skid support posts. Minor cracks were noted at the bottom of the support posts in contact with the skids. No other significant observations noted.
10. **TEST CONCLUSION:** Passed MIL-STD-1660 testing.

11. PREPARED BY:

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WILLIAM R. MEYER
General Engineer, Validation
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DATE: 3-31-00

12. SUBMITTED BY:

Jerry W. Beaver
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for Mike Bishop
MARK C. JORDAN
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DATE: 4/4/00

14. APPROVED BY:

William F. Ernst
WILLIAM F. ERNST
Associate Director for
Engineering

DATE: 4/4/00

PART 7 - DRAWING

APPENDIX 60

UNITIZATION PROCEDURES FOR AMMUNITION AND COMPONENTS PACKED IN CYLINDRICAL METAL OR PLASTIC CONTAINERS ON 4-WAY ENTRY METAL PALLETS

2.75" HYDRA ROCKET, PACKED 4 PER PA150
CYLINDRICAL METAL CONTAINER, UNITIZED
12 PER 78.50" X 29.31" SPECIAL METAL
PALLET; APPROX CONTAINER SIZE 78.50" L
X 9.25" W X 9.25" H

NOTICE: THIS APPENDIX CANNOT STAND ALONE BUT MUST BE USED IN CONJUNCTION WITH
THE BASIC UNITIZATION PROCEDURES DRAWING 19-48-4231-20PM1006.

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REVISION NO. 2		CLASS	DIVISION
FEBRUARY 1998		19	48
SEE THE REVISION LISTING ON PAGE 2		DRAWING	FILE
		4231/ 60	20PM 1006

PROJECT CA 243/60-87

PALLET UNIT DATA				
ITEMS INCLUDED		HAZARD CLASS AND DIVISION •		APPROX WEIGHT LBS
NSN	DDIC	DD CLASS	COMP GROUP	
1340-				
01-379-7814	H165	(04)1.2	E	2,239
01-289-4719	H184	(04)1.2	G	2,239
01-379-6347	H463	(05)1.2	G	2,239
01-379-7780	H463	(05)1.2	G	2,239
01-379-6350	H464	(04)1.2	E	2,239
01-379-7797	H464	(04)1.2	E	2,239
01-379-7889	H974	(05)1.2	G	2,239
01-446-4095	HA14			2,239
01-446-4097	HA15			2,239

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REVISIONS

REVISION NO. 1, DATED MARCH 1996, CONSISTS OF:

1. ADDING ITEM BY NATIONAL STOCK NUMBER TO "PALLET UNIT DATA" CHART.
2. CHANGING GENERAL NOTE "H" ON PAGE 3.
3. CHANGES IN ACCORDANCE WITH ECP MST3003.

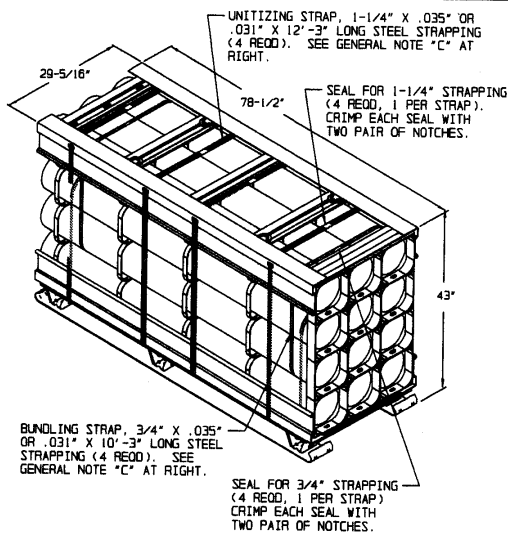
REVISION NO. 2, DATED FEBRUARY 1998, CONSISTS OF:

1. DELETING GENERAL NOTE RELATING TO STRAP CUTTER AND RE-LETTERING OTHER GENERAL NOTES.
2. CHANGING THE STORAGE DRAWING NOTE ON PAGE 3 TO REFLECT 19-48-4250/60-1-2-3-4-14-22PM1004.
3. ADDING ITEM BY NATIONAL STOCK NUMBER TO "PALLET UNIT DATA CHART" AND UPDATING THE HAZARD CLASS.
4. CHANGES IN ACCORDANCE WITH ECP RBA3002.

PAGE 2

PROJECT CA 243/60-87

DRAWING 19-48-4232/60



PALLET UNIT

SEE GENERAL NOTE "B" AT RIGHT.

12 CONTAINERS OF 2.75 HYDRA ROCKETS	
(4 PER CONTAINER) AT 162 LBS	1,944 LBS (APPROX)
DUNNAGE	185 LBS
PALLET	110 LBS
TOTAL WEIGHT	2,239 LBS (APPROX)
CUBE	57.3 CU FT (APPROX)

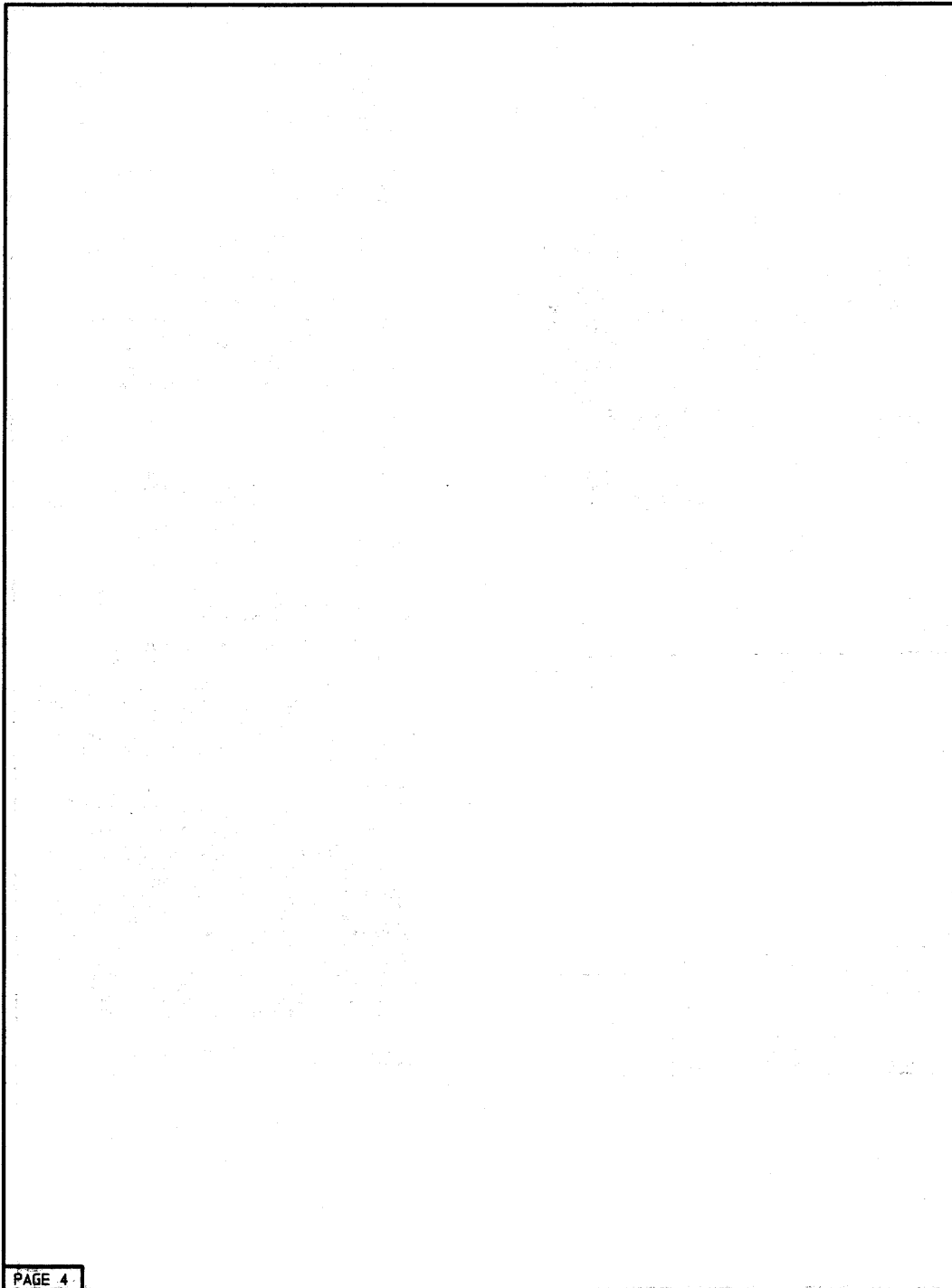
BILL OF MATERIAL

METAL PALLET, 78.50" X 29.31"	1 REQD	110 LBS
TOP ASSEMBLY	1 REQD	90 LBS
BOTTOM ASSEMBLY	1 REQD	85 LBS
STEEL STRAPPING, 3/4"	41.00' REQD	2.93 LBS
STEEL STRAPPING, 1-1/4"	49.00' REQD	7.00 LBS
SEAL FOR 3/4" STRAPPING	4 REQD	NIL
SEAL FOR 1-1/4" STRAPPING	4 REQD	NIL

GENERAL NOTES

- THIS APPENDIX CANNOT STAND ALONE BUT MUST BE USED IN CONJUNCTION WITH THE BASIC UNITIZATION PROCEDURES DRAWING 19-48-4231-20PM1006. TO PRODUCE AN APPROVED UNIT LOAD, ALL PERTINENT PROCEDURES, SPECIFICATIONS AND CRITERIA SET FORTH WITHIN THE BASIC DRAWING WILL APPLY TO THE PROCEDURES DELINEATED IN THIS APPENDIX. ANY EXCEPTIONS TO THE BASIC PROCEDURES ARE SPECIFIED IN THIS APPENDIX.
- DIMENSIONS, CUBE AND WEIGHT OF A PALLET UNIT WILL VARY SLIGHTLY DEPENDING UPON THE ACTUAL DIMENSIONS OF THE CONTAINER AND THE WEIGHT OF THE SPECIFIC ITEM BEING UNITIZED.
- BUNDLING STRAPS MUST BE TENSIONED AND SEALED PRIOR TO THE APPLICATION OF THE UNITIZING STRAPS. BUNDLING STRAPS MUST ALSO BE INSTALLED AS CLOSE TO THE OUTER RINGS AS POSSIBLE, TO AVOID DAMAGE TO THE CONTAINER.
- ALTHOUGH THE CONTAINERS DEPICTED IN THE UNIT LOAD AT LEFT ARE CONSTRUCTED WITH INTERLOCKING DEVICES, THE INTERLOCKS WILL NOT FUNCTION PROPERLY UNLESS THE CONTAINERS ARE POSITIONED SO THAT THE "PINS" OF THE INTERLOCKS ARE FACING UPWARD. THIS ORIENTATION WILL AID IN THE PREVENTION OF CONTAINER MOVEMENT, BOTH LATEROALLY AND LONGITUDINALLY, DURING SHIPMENT OF THE UNIT LOAD.
- THE FOLLOWING AMC DRAWINGS ARE APPLICABLE FOR OUTLOADING AND STORAGE OF THE ITEMS COVERED BY THIS APPENDIX.

CARLOADING	19-48-4242/60-SPM1004
TRUCKLOADING	19-48-4243/60-11PM1004
STORAGE	19-48-4250/60-1-2-3-4-14-22PM1004
END OPENING ISO CONTAINER	19-48-4245/60-15PM1009
MILVAN	19-48-4244/60-15PM1008
SIDE OPENING ISO CONTAINER	19-48-4272/60-15PM1016
- IF ITEMS COVERED HEREIN ARE UNITIZED PRIOR TO ISSUANCE OF THIS APPENDIX, THE CONTAINERS NEED NOT BE REUNITIZED SOLELY TO CONFORM TO THIS APPENDIX.
- FOR DETAILS OF THE PALLET AND PALLET ADAPTERS, SEE AMCCOM DRAWING ACV00156, MIL-A-70788 AND MIL-P-70786.
- THE UNITIZATION PROCEDURES DEPICTED HEREIN MAY ALSO BE USED FOR UNITIZING 2.75" HYDRA ROCKETS WHEN IDENTIFIED BY DIFFERENT NATIONAL STOCK NUMBERS (NSN) THAN WHAT IS SHOWN ON PAGE 2, PROVIDED THE CONTAINER PACK DOES NOT VARY FROM WHAT IS DELINEATED HEREIN. THE EXPLOSIVE CLASSIFICATION OF OTHER ITEMS MAY BE DIFFERENT THAN WHAT IS SHOWN.
- EMPTY OR REJECT PAISO CONTAINERS WILL BE USED AS FILLER CONTAINERS AS NECESSARY. FILLER CONTAINERS MUST BE INSTALLED IN THE MIDDLE OF THE TOP LAYER(S) OF CONTAINERS. IF THREE FULL CONTAINERS ARE TO BE OMITTED, ONE FULL LAYER OF CONTAINERS WILL BE OMITTED. WHEN (REJECTED) FILLER CONTAINERS ARE USED IN PLACE OF OMITTED CONTAINERS TO COMPLETE A LAYER ON A PALLET, THEY WILL BE MARKED AS SPECIFIED WITHIN MIL-STD-129-1, EXCEPT WHEN (EMPTY/REPAIRABLE) CONTAINERS ARE USED IN PLACE OF OMITTED CONTAINERS TO COMPLETE A LAYER ON A PALLET; THE WORD "EMPTY" WILL BE STENCILED IN ORANGE ON THE EMPTY CONTAINER IN 1-INCH SIZE LETTERS. THE WORD "EMPTY" WILL BE STENCILED TWICE ON THE OPEN END PORTION OF THE CONTAINER WITH THE WORDS PAINTED ALONG THE CIRCUMFERENCE, 180 DEGREES APART, AND THREE TIMES ON THE BODY PORTION OF THE CONTAINER WITH THE WORDS PAINTED LENGTHWISE ON THE CONTAINER AND SPACED 120 DEGREES APART AS MEASURED AROUND THE CONTAINER CIRCUMFERENCE.
- FOR DETAILS OF THE PAISO CONTAINER SEE PICATINNY DRAWING 12937856-2.



PAGE 4

PROJECT CA 243/60-87

DRAWING 19-48-4231/60